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Second pair of male legs and external seminal duct, posterior view ; 52 ; Third legs of male, posterior view ; 53 ; Fourth legs of male, posterior view ; 54, Fifth legs of male, posterior view ; 55 ; Sixth legs of male, posterior view ; 56. Male genitalia, anterior view ; 57. Same, posterior view.

EMBRYOLOGY.¹

Conjugation of the Brandling (continued from page 1027).—It is an error to suppose that there is any great accuracy of adjustment of ring to ring in this process of conjugation ; there are no openings of one to be brought opposite to openings in the other but only the long girdle to be applied to the region of the sperm receptacles which open between the ninth and tenth and the tenth and eleventh rings. When the girdle envelopes this region, as seen in the two-constricted parts of the figure, the enlarged intermediate region with the openings of the male ducts may be drawn backwards or forwards without need of accurate coincidence with certain rings on the other worm.

Having hardened conjugating brandlings after killing in boiling water we may cut sections of the two and obtain some insight into the anatomical relations of various parts during, or at least at any given stage of the process of sexual interchange. In longitudinal median sections we find such conditions as are indicated in figure 2 which represents the true relative size and positions of the organs although small details are omitted and the organs are represented in a conventional way. We see the somewhat free head end of the upper worm then the constricted region, the long swollen region, the second constricted part and the head end of the lower worm.

Examining the upper worm from the head backward we see that in the first-eight rings the digestive tract has a large muscular and glandular thickening of its dorsal wall, that the brain lies in the cavity of the third ring while the nerve cord is shown ventrally just as in the normal worm at ordinary times. The ninth and tenth rings form a small swelling sharply cut off by very deep constrictions of the body wall from the regions in front and behind. In these two rings the diges-

¹ Edited by E. A. Andrews, Baltimore, Md., to whom abstracts, reviews and preliminary notes may be sent.

tive tract is reduced to a more slender tubule with scarcely any lumen. The main bulk of this region is made up by the seminal receptacles two of which are shown as swollen bags full of fresh sperm. There are in all four such bags two opening between the 9th and 10th and two between the 10th and 11th; as indicated in this figure the openings of those bags are tubules that run out through the body wall on the dorsal side, not on the median line but some distance right and left.

Immediately after the region of the sperm receptacles follows the long enlargement that reaches from the 12th to 25th rings inclusive. Here the digestive tract enlarges as the soft-walled crop in the fifteenth and sixteenth rings and then narrows as the gizzard with very thick walls. Then from about the eighteenth ring the intestine runs back as a much distended tube full of liquid. The great accumulation of liquid in this swollen part of the body between the two constricted areas is a marked feature; the same congested state pertains to the dorsal blood vessel which is seen as a very thick tube dorsal to the intestine though in the constricted sperm-receptacle region it is reduced to a scarcely observable and collapsed state.

What gives this long intermediate region its excessive plumpness and distended appearance at the anterior end, where it seems to overhang the first constriction as seen in fig. 1, is the presence of the huge sperm vesicles, or as they are sometimes called testes, which are quite full of sperm in various stages of development. They are roughly indicated in figure 2 as large dorsal bags in the 12th to 16th rings. The body wall in this region is thin from distension and the diameter of the section is great from the presence of these seminal receptacles, the gorged intestine and blood vessel and the accumulated liquid of the body cavity.

The following region, from the 26th to 33rd rings is the girdle. It has a much thickened glandular wall and is contracted so that the section is small, the intestine, body cavity and blood-vessel all compressed. Just posterior to this the section enlarges and the organs take on a more normal state of expansion.

Looking now at the lower worm we find the anterior part essentially as in the first case but the next region is even more powerfully constricted so that these 9th and 10th rings make but a very small showing in the entire section.

One of the sperm receptacles is crowded back out of this region into the greatly enlarged part that follows. The constriction between the two regions has here taken place in the middle of the eleventh ring and the pressure has forced the posterior seminal receptacle of the small contracted region into the large mass that holds the seminal vesicles.

In the elongated region from the twelfth to the twenty-sixth rings the distension of the intestine and the great protuberance caused by the large crowded lobes of the seminal vesicles are even more pronounced than in the other worm.

The girdle is much contracted and constricted towards the ends in such a way that its thickened glandular wall extends both forward and backward beyond the constrictions into the neighboring regions.

From such sections we learn that the girdle and the region opposite it and containing the seminal receptacles are much contracted while the long intermediate region between the girdle is correspondingly distended. The ends of the girdle contractions are markedly constricted as deep annular grooves in which coagulated mucous serves as a cord to bind the two worms firmly together. The distended region is the one that contains the seminal vesicles full of sperm and the openings of their ducts on the fifth ring.

In a series of transverse sections of the anterior portions of two conjugating brandlings the condition of affairs at the contracted girdle region is especially striking. As shown in figure 5 one worm more than half envelopes the other. The upper part of the figure is the girdle region with its thick glandular and thinner muscular parts of the body-wall on the dorsal and lateral sides but with a much attenuated body-wall on the ventral side, which is pushed in so that the lateral parts hang down and form a deep trough for the reception of the other worm. The other worm, below in the figure, is so much contracted that the muscular part of its body wall is very thick and it is moreover thrown into folds that farther increase its extreme diminution in diameter. Its body cavity is very small and the digestive tract in it reduced to a minute tube as compared with the intestine in the other half of the section, in the girdle region of the other worm. In this shrivelled part of the worm enveloped by the girdle we see the ducts or outlets of two of the seminal receptacles, full of ripe sperm that stains deeply and is indicated in black.

This section passes nearly between the ninth and tenth or tenth and eleventh rings of the worm enclosed below by the girdle of the worm above which is cut across about the twenty-eighth to thirtieth ring.

The figure also indicates a cuticle like membrane passing from the girdle completely over the dorsal side of the other worm; this is hardened mucous that lies close to the worms and binds them together. At the same time there is a small space left between the epidermis and this mucous cuticle and in this we find ripe sperm, especially, as indicated in the figure, in the angles where the surfaces of the two worms separate.

As the sperm stains very darkly it may be easily recognized in sections. It is found in the sperm ducts of both worms as well as in the sperm receptacles, where some of it is not even now ripe. It is also seen issuing out of the openings of the sperm ducts onto the outside of the body in both animals. There it may be traced for some distance as it is held beneath the pseudo-cuticle of mucous that envelopes the worms. Especially abundant along lateral lines it rises up onto the dorsal side of the worm enclosed by the girdle and may there be seen collected about the openings of the seminal receptacles and traced into the short ducts of these organs to the mass that more or less fills up these four bags in all the conjugating brandlings as yet studied.

The anatomical evidence thus shows that in the conjugation of brandlings the girdles form grasping organs that envelope the part of the other worm containing the seminal receptacles and that a secretion, probably from the girdles, binds the two worms firmly together at these two regions. It also demonstrates that both worms pour out sperm onto the outside of the body and that this passes some distance backwards and not forwards along the sides of the worms and is finally taken into the seminal receptacles. We cannot, however, decide from these sections whether none of the sperm of one animal enters its own receptacles, but there is nothing to militate against the facts observed on the live *Lumbricus*, by Hering, that is the passing of two currents of sperm, each backward from its orifice to the girdle and so into the other animal and the sections indicate that no sperm passes forward to the animals own receptacles.

In the main the process of conjugation in the brandling as deduced from the anatomical relations of preserved pairs harmonizes exactly with the observations made upon the live *Lumbricus* and as we have seen by sectioning conjugating *Lumbricus* that the anatomical relations are almost the same as in the brandling we have little doubt that direct observation upon the brandling when they are made, will be largely a confirmation of Hering's account.

Yet the action of the girdle may be somewhat different since the dorsal opening of the seminal receptacles in the brandling as compared with the ventral opening in *Lumbricus* makes it difficult to understand how such movements of the girdle as described above by Hering can collect the sperm about the openings of the receptacles though they might bring it to the lateral positions shown in fig. 5. In the brandling even more than in the large *Lumbricus* we may suppose with Hering that same sucking action of the receptacles may be concerned in taking in the sperm.

We are probably not far wrong in concluding that conjugation is essentially the same in *Allolobophora foetida* and *Lumbricus terrestris*.

In addition to filling the sperm receptacles of the other worm conjugation commonly leaves a trace in the form of the so-called spermatophores, or penis of Hering and older writers, which may here receive attention less from their intrinsic value than from their bearing, though it be slight, upon the important suggestion advanced by Professor Whitman namely that spermatophores might have been the original means of transferring sperm and only later superceded, in most animals, by localized organs for transmission. Though in the earthworms the foreign sperm is discharged from the receptacles when the eggs are laid and fertilizes them outside the body it might be supposed that these spermatophores in question were remnants of a formerly useful apparatus for putting sperm from one animal into the other, such as is found in some leeches. In the brandling, however, the indications seem rather to favor the idea that the spermatophore here is in a sense accidental and of no historical value so that it cannot be relied upon in extending the condition found amongst leeches to other groups, even if related.

When conjugating brandlings are separated we often find upon one or the other or both such spermatophores as are indicated in fig. 3. They are conspicuous white specks that soon turn yellow-brown though preserving a milk-white central elevation.

When pulled off from the epidermis, to which it adheres quite firmly at first, each is a homogeneous membrane or hardened secretion with a central cavity full of ripe sperm that moves when crushed out.

In a section of such a spermatophore attached between two rings we see, in figure 4, that it is very closely attached to the epidermis and that it ends abruptly, in fig. 3 it is seen to have a ragged edge and may also present outlying bits separately attached to the skin. The contained sperm lies in layered masses as if ejected into a stiffening jelly; moreover this mass is not entirely closed in as the section, fig. 4, would indicate but lies in a pit or pouch that opens at the top, in other sections, so that the sperm may be squeezed out in a fresh specimen. The spermatophore is thus a mass of sperm lying in an irregular cup of some tough secretion that is spread out on the skin and stuck to it.

Of 220 live brandlings taken at the conjugating season of the year 84 had spermatophores attached at about the 22nd ring of the body. Generally there are two sometimes but one, generally they are attached so as to cover the groove between two rings as in fig. 4 but often they are on the face of a ring as in fig. 3.

Of fifteen pairs taken in conjugation May 8th, 1892, five had spermatophores as follows: two symmetrically placed, between rings 22 and 23; one on the right side of the 23rd; two symmetrically placed on the 23rd; one on the left between the 23rd and 24th; two symmetrically placed on the 24th.

The region in which these bodies are found, the 22nd to 24th rings is opposite to the openings of the male organs of the other animal during conjugation, as already emphasized and indicated in figs. 1 and 2, and as the distance between the bodies, when there are two, is equal to that between the two male openings we are led to infer that these spermatophores are formed where the male openings are pressed against the other animal.

In serial transverse sections we find where the sperm is issuing from the male openings a condition of things such as is indicated in fig. 6. In the angle between the sides of the two worms just exterior to the closely applied ventral surfaces there is a considerable accumulation of sperm which is continuous with that issuing from the male opening. This extends backwards along the side of the worm that is ejecting it and is covered over by a dense, mucous, cuticle-like membrane as indicated in the figure. The glands near the male opening are evidently active and pouring out a dense secretion which fills up most of the space between the two worms and partly envelopes the large sperm mass. We have here what seems to be, with little doubt, a spermatophore in process of formation; the secretion of the glands about the male opening forms a dense mass adhering to the other worm and receiving in its substance a considerable collection of sperm as it issues forth. When the worms separate the secretion should adhere to the worm opposite to the male opening and leave in it a little mass of sperm; thus might arise spermatophores as are shown in fig. 3.

If the spermatophores are formed in this way as entangling of some sperm in a local secretion about the male opening and are stuck to the other worm they might still be of use in fertilizing the eggs of that worm when they pass into the egg capsule for the egg capsule would glide forward from the girdle over the region where the spermatophores are stuck and perhaps carry them off. But it is very doubtful if the spermatophores remain attached till the eggs are laid. Of twenty-two worms bearing spermatophores not one had them after forty-eight hours when kept in confinement, nor were any eggs laid in that time.

Though we regard the spermatophore as an accidental or at least useless structure as far as it has to do with any preservation of sperm we would not deny that the secretion about the male opening has a use whether sperm sticks in it or not.

Possibly this dense mass may serve to check the spreading of sperm in a forward direction and make more certain its passage backward towards the region where it can reach the receptacles of the other worm.

The balance of evidence seem to be that the spermatophores of the brandling, and by inference those of other earthworms too, are of no use after the process of conjugation is finished, that they do not serve to convey sperm and hence are not spermatophores at all in any proper sense of the word.—E. A. ANDREWS.

PSYCHOLOGY.¹

Criminology.—In a series of articles on *Les Règles de la Méthode Sociologique*, recently contributed to the *Revue Philosophique* (May, June, July and Aug., 1894), Prof. Emile Durkheim, of Bordeaux, has taken occasion to advance a somewhat novel theory of crime and its relation to the normal social organism. This he restates and reaffirms in the May number, 1895, in reply to a rather intemperate attack made by M. G. Tarde in February. The whole controversy is of interest as showing how easily familiar facts assume a new and even paradoxical guise when put in ambiguous language.

Prof. Durkheim finds his point of departure in the impossibility of getting from the subjective or the teleological points of view any satisfactory definition of the concepts *normal* and *pathological*. The morbid is not necessarily painful *e. g.*, hysterical anæsthesia and, *vice-versa*, the painful is sometimes normal, *e. g.*, menstruation, parturition. The normal cannot be defined as that which is adapted to its environment, for it is not proved that every state of the organism must be adapted to some external state, and, in any case, we lack a criterion to judge between greater and less degrees of adaptation. Nor is the normal that which is fitted to survive, since, *e. g.*, infancy and old age are normal, and, on the other hand, many morbid states do not appreciably shorten life. There remains, then, only one suitable meaning which we can give these words. The normal is the general, the usual, the average. The abnormal, morbid or pathological is the exceptional and unusual. It follows then that the conception of a healthy organism is practically identical with that of the organism as such. Health will also be

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